

On the Occurrence of *Amphidinium operculatum*, Clap. & Lach., in vast Quantity, at Port Erin (Isle of Man). By Prof. W. A. HERDMAN, F.R.S., F.L.S.

(PLATE 8.)

[Read 1st June, 1911.]

IN going to and fro between the village of Port Erin and the Biological Station, during the recent Easter vacation, I had occasion to take a short cut across the sandy beach at least twice and sometimes six times in the day. One gets into the habit, in these traverses, of looking closely at the beach when the tide is out, on the chance of seeing something of interest cast up. On April 7th, I noticed a new and quite unusual appearance on the sand at or a little above half-tide mark. The hollows of the ripple-marks and other slight depressions formed by the water draining off the beach were occupied or outlined by a greenish-brown deposit which in places extended on to the level so as to discolour patches of the sand (see Pl. 8. fig. 1).

Here the deposit remained, more or less, for a month—waxing and waning, sometimes increasing in a tide, say, roughly tenfold, and at other times apparently disappearing for a day or two and then re-appearing either on the same part of the beach, or it might be a few hundred yards away. At one time it discoloured a continuous stretch of sand about 50 yards long by 5 yards in breadth just below high-water mark, and was noticeable from some distance away.

At the first glance I supposed the appearance was caused by a deposit of Diatoms, but on taking a sample to the laboratory, microscopic examination showed that although a few diatoms (including *Navicula Amphisbæna**, or a closely allied form) were present, the deposit was formed almost wholly of enormous numbers of a very active little Peridinian or Dinoflagellate of a bright yellow colour. More careful investigation enabled me to identify this form as *Amphidinium operculatum*, described by Claparède and Lachmann, in 1858, from specimens obtained at Christiansand, Bergen, and a few other places in Norway.

The published records of *Amphidinium*, however, do not give the impression that it is a common or abundant organism. The latest comprehensive work on such forms—the article on Peridinales, by Paulsen, in the 'Nordisches Plankton' (Kiel, 1908)—recognises 4 species of *Amphidinium*: *A. crassum*, *A. rotundatum*, and *A. longum*, which as yet have been recorded from Kiel

* See postscript at end of this paper.

only; and *A. operculatum*, which is stated to occur in brackish water on the north coasts of Europe. In addition, Kofoid ('Dinoflagellata of the San Diego Region,' 1907), records *A. lacustre* from fresh water, *A. aculeatum*, a pelagic form from Naples, and *A. sulcatum*, which he took in a vertical haul from 90 fathoms in the Pacific.

On hunting through the few scattered references to *A. operculatum* which occur, one finds, however, that R. S. Bergh, in the 'Zoologischer Anzeiger' for 1882, states (p. 693) that Spengel in December and January found it in huge quantities on the beach at Norderney. Although, therefore, *Amphidinium operculatum* has been recorded once before as occurring in quantity, the occurrence appears to be a sufficiently rare event to be worthy of notice; and, so far as I can ascertain, the species, although known from several parts of North-west Europe, has not been previously found on the British coasts. I have written to most of the marine laboratories (Plymouth, Cullercoats, St. Andrews, and Millport) and to many marine biologists and have not been able to hear of any British record.

It is, however, not an unknown thing for rare Dinoflagellates to appear suddenly in some locality on an occasion in phenomenal quantities. Torrey, in the 'American Naturalist' for 1902, describes the unusual occurrence of a species of *Gonyaulax* on the coast of California. Sherwood and Vinal Edwards, in the 'Bulletin of the United States Bureau of Fisheries' for 1901, tell how for two weeks in September a *Peridinium* infested Narragansett Bay in such numbers as to colour the water blood-red and cause the death of many fishes.

Finally, Whitelegge, in the 'Records of the Australian Museum' for 1891, gives an interesting account of a new species of *Glenodinium* (*G. rubrum*) which appeared in such quantities in Port Jackson as to give the water "the appearance of blood" and cause the death of great numbers of oysters, mussels, and all forms of shore life. Whitelegge supposed that the very heavy rainfall that year, by affecting the salinity of the water, and then a lengthened period of calm weather which followed, may have provided favourable conditions for an unusual development of the Dinoflagellata. The *Glenodinium* appeared in vast numbers about the middle of March and disappeared early in May. When it was at its climax, the allied colourless species *Gymnodinium spirale* appeared in the bay and soon increased greatly in numbers and became finally even more abundant than the red *Glenodinium* upon which it was evidently feeding.

Returning now to our *Amphidinium operculatum*, it is not easy to account for the sudden appearance of this unusual Dinoflagellate (previously unrecorded in Britain) in such profusion on the beach at Port Erin last April. Plankton hauls were being taken regularly across the bay at the time, and they showed no trace of the organism. In fact, *Amphidinium* has not occurred in any of the thousands of gatherings which we have taken in the

Irish Sea during the last four years, and which have been examined in minute detail by Mr. Andrew Scott, A.L.S.

Thinking it might be present in the shallow water close to the edge of the beach, Mr. W. Riddell and I took some hauls of the tow-net from a punt worked backwards and forwards in a few inches of water as near as we could get to the discoloured sand, but the gathering, although it contained fine sand and mud, showed no trace of our Dinoflagellate. It may be noted here that although the size of the *Amphidinium*, 0·05 mm. in greatest diameter, is such that it can slip through the mesh (averaging about 0·08 mm.) of the finest plankton silk (no. 20), still so much clogging of the meshes always takes place in such hauls, and so many other smaller organisms and particles of mud are retained, that it is certain that had the *Amphidinium* been present in any quantity in the water it would have shown up in the gatherings.

Careful scraping of the sand showed that the Dinoflagellates were only in and on the surface-layer, and therefore could not be regarded as coming up from below. It occurred to us that possibly they might be fresh- or brackish-water forms derived from the land; but we ascertained that the little stream in the centre of the bay, which in wet weather overflows on to the beach (at other times it is conveyed into the town sewer), had not, on account of the unusually dry season, sent any water to the beach for some weeks. Moreover, on experimenting with the living *Amphidinium* in the laboratory, we found that while it lived well in sea-water it died at once in fresh and survived for a few days only in brackish water. Samples of the *Amphidinium* kept in shallow dishes of wet sand at the Biological Station in a few days showed such profuse growth that the sand was covered by a dark-coloured layer, the water became impure, and eventually all the Dinoflagellates died off.

Observation under the microscope shows that although this is a singularly active Dinoflagellate, circling round and round with great vigour, so that a drop of sand and water containing a number of the organisms presents a most animated picture under a low power magnification, still the *Amphidinium* seems to be actually attracted to the sand-grains and associated with them. The sand-grains in the field of view are always peppered over with a number of specimens of the *Amphidinium* (Pl. 8. figs. 2, 3, 4), and if individuals be watched they are seen after swimming round to come back to rest on a sand-grain and remain there for a time before starting off on another excursion. If they are thus constantly associated with sand-grains or other solid particles, and never swim more than a microscopic distance from such a resting-place, that may account for the fact that we have never found them in our plankton gatherings.

Amphidinium operculatum is also, however, positively heliotropic, congregating in quantity on the lighter side of the dish in the laboratory, and

shifting in bulk from the sand at the darker part of a tank to the end nearer the window. This property accounts for the invariable occurrence of the discoloured sand on the surface only and never in the deeper layers.

The published figures of this species are not very good, so a view of both dorsal and ventral surfaces, as seen under a high magnification, is given here (Pl. 8. fig. 5). There certainly seems to be a slight but definite cuticle covering the greater part of the surface, although this has been denied by some previous writers. The two characteristic Dinoflagellate grooves certainly join, as is stated by Calkins but not by other observers.

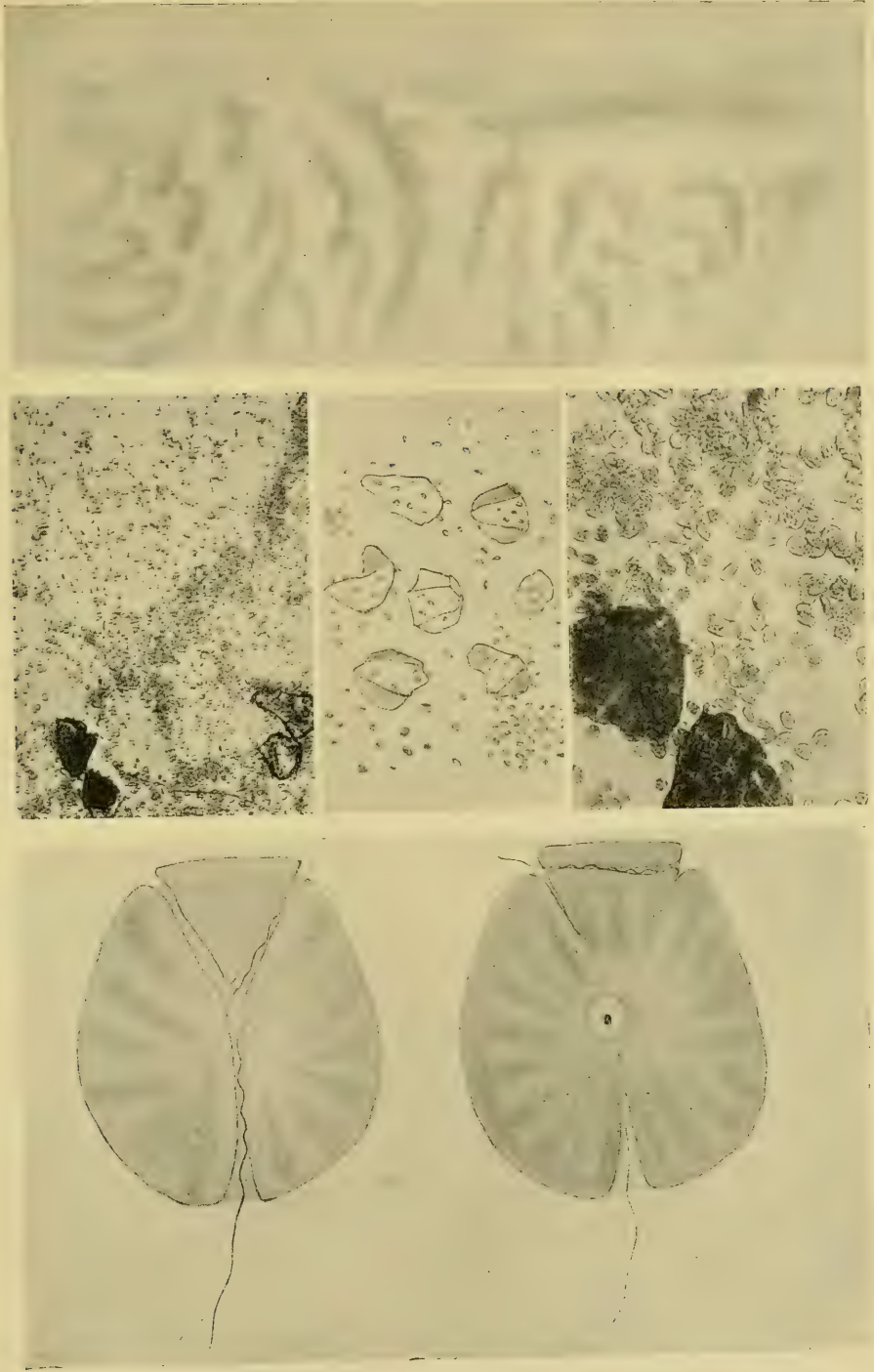
The posterior flagellum which projects freely from the body is not difficult to see, but the anterior one which lies along the transverse groove is not so easy to demonstrate, and may differ a little in position and extent from what is shown in the figure.

Stages in longitudinal fission were frequently seen, and that is probably the commonest method of reproduction. What appeared to be conjugation between two individuals was observed in one instance.

It may be that this organism lives normally in small quantities, so as not to be conspicuous, in some region of the sandy beach, or possibly in some special habitat beyond the beach, and that the present vast increase in numbers has been due to some unusual conjunction of circumstances; but what these were I am not prepared to suggest. In the case of the Port Jackson *Glenodinium* plague, Whitelegge thought the increase may have been due to exceptional rainfall and calm weather; but the occurrence this spring at Port Erin was preceded by unusually dry, but rather stormy, weather.

I am inclined to think that, although I can find no previous record of such an occurrence, it is probable that these swarms of *Amphidinium* have been seen before at Port Erin, and possibly elsewhere. I fancy I have seen the phenomenon myself in the past, and have supposed it to be due to swarms of Diatoms, which certainly do cause some of the yellowish-green and brownish-green patches on the sand between tide-marks.

POSTSCRIPT, *June 5th*, 1911.—Two days after reading the above paper before the Linnean Society I was again on the beach at Port Erin. I found in the same region what was apparently the same patch of discoloured sand, but on examining a scraping with the microscope found that the deposit was now wholly composed of a golden-yellow Naviculoid Diatom—one of the "*Amphisbena* group" of *Navicula*. I have searched the beach carefully between tide-marks, and have examined samples from every suspected patch of sand, but can find no trace of *Amphidinium*. The *Navicula*, which was present in April in very small quantity (see above), seems to have completely replaced the Dinoflagellate. We have probably still much to learn in regard



AMPHIDINIUM OPERCULATUM.

to the comings and goings of such microscopic forms and their physiological inter-relations in connection with what may be called "the metabolism of the beach."—W. A. H.

Sept. 9th.—The *Amphidinium* is now back again in abundance, and the Diatoms are absent.—W. A. H.

EXPLANATION OF PLATE 3.

- Fig. 1. The general appearance of the brown deposits in the ripple-marks on the sand, reduced in size.
2. Sand-grains and *Amphidinium* (photo-micrograph under low-power magnification).
 3. Sketch from living preparation, to show some *Amphidinia* resting on the sand-grains and others swimming about (low power).
 4. Part of fig. 2 under high-power magnification.
 5. Dorsal and ventral views of *Amphidinium operculatum*—enlarged from high-power magnification.

For the photo-micrographs reproduced as figures 2 and 4, I am indebted to my friend Mr. Edwin Thompson.